

1 GASEOUS FUEL PRODUCTION FROM FRAGMENTARY CARBON-RICH FEEDSTOCK
2

3 TECHNICAL FIELD

4 This invention concerns conversion of fragmentary carbon-rich
5 feedstock by electrical arcing into non-self-combustible gas whose
6 air-combustion effluent is free from noxious gases and particulates.
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8 BACKGROUND OF THE INVENTION

9 Underwater arcing of carbon in rod or other continuous form to
10 generate fuel is well known, as shown by the following U.S. Patents:
11 Richardson 6,299,738 6,299,656; 6,263,838; 6,153,058; 6,113,748;
12 5,826,548; 5,792,435; 5,692,459; 5,435,274; Lee et al. 6,217,713;
13 Dammann 6,183,608; 5,417,817 (et al.); 5,159,900; Eldridge 603,058.
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15 SUMMARY OF THE INVENTION

16 This invention enables commercially successful production of
17 non-self-combustible gaseous fuel, combustible--upon addition of air
18 or similar oxygen source--into heat and effluent substantially free
19 of noxious gases, and free of liquid and solid particulates, by
20 electrically converting wetted compacted fragmentary carbon-rich
21 feedstock (e.g., anthracite, graphite, carbon residues) low in gross
22 contaminants, into such environmentally beneficial gaseous product.

23 In semi-continuous operation, such conversion is achieved in a
24 high-temperature reactor, by emplacing, compacting, and wetting such
25 feedstock, exposing feedstock so treated to electrical arcing, thus
26 evolving desired gaseous product, and collecting it thereabove. Any
27 unconverted feedstock may be treated further, or may be replaced.

28 Feedstock is emplaced, manually or mechanically, to desired
29 depth within such reaction zone, is wetted and is compacted therein
30 as described below. Optimal depth depends upon carbon concentration
31 and degree of fragmentation of the feedstock, preliminary wetting
32 thereof, electrical conductivity of its constituent(s) so treated,
33 the degree of indentation and/or penetration by the electrodes, and
34 the voltage and timing of electrical power application thereto.

35 The extent of wetting of the fragmented feedstock may range
36 from initial coating of its surface to complete flooding thereof,
37 the latter generally being preferable eventually, if not initially.

1 Emplaced feedstock is wetted, as and when desired, via outlets
2 from water piping in (or on) the reaction zone sidewalls, composed
3 of heat-resistant materials and cooled by circulation of refrigerant
4 liquids via (other) piping therein so as to protect them from the
5 very high temperatures characteristic of electrical arcing.

6 This invention provides a compacting and arc-inducing module
7 having three major components, comprising from top to bottom: (i) at
8 fixed height, a reservoir, conveniently supported at a fixed level
9 from the reactor sidewalls, into (and through) which water flows at
10 a controllable rate; (ii) communicating with the reservoir base, the
11 largest of several vertically telescoping hollow cylinders--their
12 extension being determined by reservoir water pressure; and (iii)
13 connecting with smallest cylinder's bottom end, hollow compressive-
14 compacting plate (supported at controllable height determined by the
15 extent of such telescoping) having an array of electrodes protruding
16 downward from its lower face, and powered by positive (+) electrical
17 connection from an (exterior) high-voltage, high-amperage source.

18 A pair of flexible electrical multi-conductors extend downward
19 from laterally spaced wind-up supply rolls overhead, pass from top
20 to bottom of the reservoir via respective vertical channels (dry)
21 therethrough, and enter the top of a so supported hollow compacting
22 and arcing electrode plate. Such electrical conductors terminate by
23 connection with respective downward protruding electrodes thereof.

24 One or more negative (-) electrical conductors on (or in) the
25 reactor floor provide(s) electrical grounding. Electrical arcing
26 occurs in and through the intervening compacted wetted feedstock and
27 thereby produces the desired gaseous product, which collects in the
28 space above the feedstock. Such non-self-combustible gas is readily
29 drawn off to be used then and there, or to be stored for later usage
30 at the reactor location, or be sent by pipeline or by transport of
31 suitable containers to storage and/or usage elsewhere.

32

33 **SUMMARY OF THE DRAWINGS**

34 Fig. 1A, 1B, & 1C are block diagrams of respective electrical,
35 mechanical, and procedural components and steps, designated by words
36 and/or symbols within the blocks or juxtaposed to intervening lines,
37 for vertical compression and arcing of fragmented wet feedstock.

1 Fig. 2 is a sectional elevation of a reactor of this invention,
2 featuring its feedstock-compacting and electric-arching module having
3 a water reservoir at a given fixed height and, suspended therefrom
4 at controllable variable height by means of intervening telescoping
5 cylinders, an electrode-carrying plate lowerable into compressive
6 compacting and arcing contact with feedstock loaded therebelow.

7 Fig. 3 is an upward-looking sectional view taken at the level
8 of a bottom-most cylinder in one such set, at (III-III) on Fig. 2.

9 Fig. 4 is an upward-looking bottom view of such electrode plate
10 supported by the noted telescoping cylinders, at (IV-IV) on Fig. 3;

11 Fig. 5 is a side sectional elevation of one such electrode,
12 with its downward protruding conical tip shown unsectioned; and

13 Fig. 6 is a side sectional view of an arc locus (and vicinity)
14 between (i) a downwardly pointed conical high-voltage electrode such
15 as shown in preceding views and (ii) an electrically grounded up-
16 wardly pointed multihedral electrode, within a mass of fragmented
17 carbon feedstock, and exhibiting bubbles of desired gaseous product
18 forming and/or formed alongside adjacent arcing feedstock fragments.

20 **DESCRIPTION OF THE INVENTION**

21 Figs. 1A, 1B, and 1C are block diagrams denoting materials and
22 related methods by words, reference numerals, and/or other symbols.
23 Located within or closely adjacent to actual blocks they designate
24 named activities, materials, etc. Spaced midway between blocks,
25 they designate flow of input or output therebetween.

26 Fig. 1A shows High Voltage Power Source 80 with electrical
27 lead(s) 82 down to On-Site Rectifier 83, leads 84 from there to
28 Electrode Sequencer 85, then leads 86 to Electrodes 87.

29 Fig. 1B similarly shows Movable Module 20 at full height (++),
30 with its suspended Electrode Array 89 at variable height (+/-), and
31 further lowerable (--) into Compacting or Compressive Contact 99
32 with Fragmented Feedstock 100 loaded therebelow.

33 Fig. 1C shows Upward Evolving Gaseous Fuel As Product 104 above
34 Arcing Compressed Feedstock 101 so Loaded into Reaction Zone, under
35 Overhead Water Spraying 102 and/or Lateral Flooding 103, becoming
36 Upward Evolving Gaseous Fuel 104 and finally Collected Gaseous
37 Product 105 for Fuel Usage 106 or Fuel Storage 107.

1 Fig. 2 shows, in elevation and partly in section, reactor 10
2 with a U-shaped reaction zone bounded by left and right sidewalls 4
3 and 6 and metal electrical grounding strip 5 on floor 6 on ground 7.

4 Each sidewall contains upper and lower channels 9 and 13
5 therein for refrigerant from conventional exterior cooling means
6 (not shown) circulated therein to protect the walls from heat damage
7 during the frequent adjacent high-temperature electric arcing.

8 Each sidewall also contains upper and lower channels 11 and 12
9 from a conventional external water supply (not shown) to respective
10 lateral outlets 18, 19 opening into the reaction zone, to enable wet-
11 tting of feedstock 100 herein, from overhead and laterally, such as
12 before and/or during--and/or after--protracted electric arcing.

13 Compacting and electric-arcing module 20 features reservoir 25,
14 itself made of (or lined with) electrically non-conductive material,
15 and retained between the respective sidewalls via collars 23 and 27
16 about adjacent in-wall water pipe end portions 24 and 26, which con-
17 tain reservoir input valve Vi and output valve Vo, respectively. The
18 reservoir contains four hydraulic lowering and raising pumps--P₁,
19 P₂, P₃, and P₄ (latter's upper spout only shown).

20 Module 20 also features hollow (electrode-containing) plate 30
21 suspended, at adjustable height below the reservoir, by intervening
22 sets of vertically telescoping close-fitting hollow cylinders. Each
23 such set comprises four thereof, increasing via intermediate sizes,
24 from 32 (the smallest) to successively larger 34 and 36 and ending
25 with 38 (the largest) connecting at its top end to the reservoir un-
26 derneath the down-spout of one of its pumps. Each of such down-
27 spouts may (or may not) extend down into its connecting cylinder.

28 Connecting each of the telescoping set's largest cylinders at
29 its top to the reservoir, and of its smallest cylinder at its bottom
30 to a matching top opening in the hollow electrode-containing plate,
31 completes four go/return water paths between reservoir and plate.

32 To apply compacting force to underlying feedstock, the hollow
33 plate is forced down by pumping water from the reservoir (with Vi
34 open and Vo closed) via the lower/raise pumps into and so extending
35 the telescoping cylinders. Reversing reservoir input/output valve
36 settings (and, thus, the pumping direction) forces water from the
37 plate back into--then out from--the reservoir, re-raising the plate.

1 Product exit valve Vx in ceiling outlet duct 45 (cut-away view)
2 is flanked by two wind-up rolls 44 and 46 of flexible electrical
3 wiring, which after passing via (dry) guide tubes 74 and 76 through
4 the reservoir from top to bottom continues to--and enters into--the
5 top of the plate. Such wiring unwinds from its roll whenever the
6 plate is lowered, and rewinds onto such roll when the plate rises.

7 Each such roll may contain not only electrode-arc wiring from a
8 high-voltage source (e.g., 80, Fig. 1) to plate electrodes, but also
9 lower-voltage leads (not separately shown) continuing upward from
10 the plate, via at least one telescoping tubing set, to energize the
11 reservoir pumps. The pump motors may be served even more simply by
12 equivalent electric leads (not shown) into the reservoir from above.

13 As fragmentary feedstocks, even with adequate concentrations of
14 suitable carbonaceous material, impose stringent requirements upon
15 electric arcing, the noted step (99) of compacting such feedstock is
16 undertaken mainly (not necessarily exclusively) before high-voltage
17 arcing potential is provided to individual electrodes (50), as may
18 be done randomly or in preplanned sequence. All or only some of the
19 electrodes may be energized with fixed or varying voltage--whatever
20 is preferred--for given feedstocks and/or during given time periods.

21 Fig. 3 shows, viewed upward from below [v. III-III on Fig. 2] a
22 representative part of lower face 51 of reservoir 25 plus the
23 (shaded) undersides 68, 66, 64, and 62--numbered from outside
24 inward--of respective telescoping cylinders 38, 36, 34, 32, shown
25 end-on as successively smaller concentric associated disks, each of
26 appreciable wall thickness, in view of their load-bearing function.
27 Centered within the smallest is similarly sturdy electrode housing
28 55 laterally surrounding electrically insulated electrode hot-lead
29 51, shown as a similarly sturdy dot at the central axis.

30 Fig. 4 shows, viewed upward from below [v. IV-IV on Fig. 2],
31 lowermost face 39 of hollow compacting-compressing plate 30. Its
32 array of conical electrode tips 50 resembles in appearance a
33 5-spotted domino face having, along each of its four edges, an added
34 row of three electrode spots each--for a total of eleven electrodes
35 (each corner electrode appearing in both of two intersecting rows).
36 Though the tips are shown much alike here, their actuation at unlike
37 voltages and/or for unlike time durations will erode them unevenly.

1 Fig. 5 shows in longitudinal section, on a much larger scale,
2 electrode housing 53 of Fig. 3 sectioned lengthwise, surrounding its
3 (insulated) hot-wire 51, whose bottom end 56 seats in indentation 57
4 in the top of (otherwise unsectioned) conical electrode 50.

5 Housing 53 (sectioned lengthwise) exhibits lateral outlets or
6 "weep holes" with flow arrows therethrough and into the surrounding
7 water, whether within the plate or below it (as shown here). Any
8 water so weeping into the plate may re-enter the reservoir via the
9 cylinders, whenever subsequently re-telescoped. Water weep-exiting
10 below the plate may be converted by the arcing into steam or even
11 (along with feedstock carbon) into the desired gaseous product.

12 Fig. 6 shows electrical arc site between a downward protruding
13 conical electrode tip 49 spaced above an upstanding quadrihedral tip
14 51 grounded by plate-like electrode 7 [in floor 8, not shown here].
15 As such arc 90 is blinding, it appears as a blank space (of rays).

16 Adjacent fragments of wet feedstock are shown as dark irregular
17 blobs on which beads of desired gaseous product are likely to appear
18 as adjacent bubbles (99), which may collect initially thereon or
19 therebetween. Such bubbles initially may expand in place by merging
20 with adjacent visible bubbles (or invisible quantities) of gas which
21 will rise and join otherwise unseen volumes thereof as an invisible
22 blanket of the desired gaseous product overlying whatever impurities
23 or unconverted feedstock may remain thereunder.

24 Such product may be collected conveniently by first flooding
25 the reaction zone--if not already flooded--via inwall water outlets,
26 then opening outlet valve Vx in cover or roof 59, which otherwise
27 seals the space overhead. A preferably oil-free gas-compressor (not
28 shown here) is useful in forwarding the collected gaseous product to
29 a storage container or to a usage location, if so desired.

30 As fragmentary feedstocks, even with adequate concentrations of
31 suitable carbonaceous materials, impose stringent requirements upon
32 electric arcing, the noted step (99) of compacting such feedstock is
33 undertaken mainly (not necessarily exclusively) before high-voltage
34 arcing potential is provided to individual electrodes (50), as may
35 be done randomly or in computerized sequence. During some or all of
36 the time, some or all of the electrodes may be "hot"--whether fixed
37 or varying in voltage--as may be preferred for a given feedstock.

1 Initial injection (as via in-wall water piping 54, 56) of a
2 slightly conductive--otherwise inert--gas, such as helium or argon,
3 and/or even so innocuous an electrolyte as acetic acid, may help to
4 initiate, or even to maintain, the essential electrical arcing.

5 After feedstock arcing is deemed satisfactorily completed in
6 any single run, voltage to the electrodes in the module plate is dis-
7 continued, and the module plate is raised from the feedstock rem-
8 nants by withdrawing water from the extended telescoping cylinders.

9 The feedstock residue then may be recompacted to be treated fur-
10 ther, or may be removed so as to be replaced by a new batch of the
11 same or equivalent feedstock of fragmented carbon-rich composition.
12 Such an interim also enables personal scrutiny or any pre-scheduled
13 replacement of any excessively corroded or non-performing electrode.
14 Though made of tungsten or its alloys with other stable heavy metals
15 any electrode will corrode and/or wear away during repeated arcing.

16 The space overhead can be diminished by replacing the indicated
17 fixed ceiling by a downwardly movable false ceiling--and by raising
18 it gradually as the desired gaseous product is formed underneath it.

19 Additionally or alternatively, the feedstock may be blanketed
20 with another relatively inert gas (e.g., carbon dioxide) or by other-
21 wise delaying gaseous fuel production until substantially all air in
22 the reaction zone has been superseded by blanketing or otherwise.

23 The preferably refrigerant-cooled reactor walls are composed of
24 readily available high-temperature-resistant material(s), preferably
25 ceramic or stone--or some combination thereof--thus rendering them
26 adequately stable despite electric-arching, wherein temperatures of
27 thousands of degrees may be reached and persist for lengthy periods.

28 The conical and/or tetrahedral feedstock-contacting electrodes
29 shown herein preferably comprise tungsten or its durable heavy-metal
30 alloys selected to withstand the encountered electric-arching and to
31 provide an adequately functional operational lifetime. Nevertheless,
32 they preferably are mounted for ready replacement, as may be needed.

33 Useful variations may be made in the subject invention, as by
34 adding, combining, deleting, or subdividing apparatus, compositions,
35 parts, or steps, while retaining many advantages and benefits of the
36 herein described invention--itself being defined more specifically,
37 as to its wide variety of useful aspects, in the following claims.